



VSTARS: A STEP Success Story



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Abstract

The End-To-End Test (ETE) is being conducted under the auspices of the Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E). The purpose of the ETE is to investigate the utility of using advanced distributed simulation (ADS) to augment both developmental and operational testing of the Joint Surveillance Target Attack Radar System (STARS). The basic concept behind the ETE is to augment the Joint STARS environment with a virtual environment created by thousands of simulated entities or targets. This virtual environment is imaged by a simulation of the radar system onboard the Joint STARS E-8C aircraft.

The simulation environment representing the radar subsystem onboard the E-8C aircraft is called the Virtual Surveillance Target Attack Radar System (VSTARS). VSTARS uses a combination of actual radar subsystem software, simulations of aircraft subsystems, and two near real-time stochastic radar simulations with necessary databases and libraries to simulate the Joint STARS radar subsystem.

VSTARS uses early engineering models and simulations and results of early developmental tests to develop a simulation that may be used to assess cost-performance trade-off, technical risk, system maturity, operational effectiveness, suitability, training, mission planning, and employment.

The adaptation of VSTARS as the primary training simulation for Joint STARS by the Air Force represents the last step (pun intended) in the application of the simulation, test and evaluation process (STEP) to Joint STARS and establishes the validity of the process in support of the Department of Defense acquisition process.

Background

The Joint Advanced Distributed Simulation Joint Test and Evaluation was chartered by the Office of the Under Secretary of Defense (Acquisition and Technology), Office of the Director, Test and Evaluation "...to investigate the utility of Advanced Distributed Simulation (ADS) for both developmental test and evaluation (DT&E) and operational test and evaluation (OT&E). JADS will investigate the present utility of ADS, including Distributed Interactive Simulation, for test and evaluation (T&E); and finally, identify the requirements that must be introduced in ADS systems if they are to support a more complete T&E capability in the future."

The End-To-End Test is one of three tests within the JADS JT&E program. The ETE is designed to evaluate the utility of ADS to support testing of a command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) system, the Joint STARS, while the system performs the end-to-end loop of detect-track-target-cue a weapons system and assesses battle damage. Joint STARS is composed of both an airborne and ground segment along with the necessary communications subsystems. The E-8 airborne system and the ground station modules (GSM) together provide the surveillance, target detection, and tracking required to assist commanders in understanding the enemy situation and taking action to destroy enemy forces.

During the feasibility study phase of JADS, it quickly became apparent that a simulation or simulations of the radar subsystem that could provide the required fidelity, operate in real time throughout the ground radar coverage area, and emulate the two radar modes, moving target indicator (MTI) and synthetic aperture radar (SAR) did not exist. Most MTI simulations represented, at best, a single operator's workstation, used estimated timelines, and performed as if they had a dedicated radar subsystem. A feasible SAR simulation did not exist. Common practice was to substitute preloaded images that often had little or no operational relevance.

If such a simulation could be developed, it could be used with existing simulations, such as the navigation subsystem simulation, to emulate the performance of the E-8 airborne radar subsystem. By adding additional subsystem simulations, hardware components, software, or fielded components, the entire Joint STARS could be represented in configurations ranging from pure simulation to an ADS-augmented fielded system.

As a result of the decision by JADS to develop such a simulation, the Virtual Surveillance Target Attack Radar System was designed by JADS and built by Northrop Grumman, Lockheed Martin, and Motorola. VSTARS is capable of functioning in a pure laboratory environment using commercial off-the-shelf equipment, in a hardware-in-the-loop environment using fielded components (primary mission equipment), and onboard the aircraft coexisting with the real radar subsystem in an ADS-augmented environment.

VSTARS uses early engineering models and simulations, the results of early developmental tests, specially developed radar emulations, and Joint STARS equipment and software to represent the E-8C subsystem. When connected to a GSM, simulated, physical prototype, or real, it represents the entire system.

Since the purpose of this paper is to talk about STEP, I will say no more about VSTARS and its development other than it has undergone a rigorous verification and validation (V&V) to include a modified Turing test. The V&V has been reviewed by a multiservice accreditation board, and it has been accredited for use in the ETE. In addition, VSTARS is currently undergoing a radar acceptance test conducted by the joint program office's joint test force similar to that conducted prior to acceptance of a production radar aircraft.

VSTARS and STEP

How then does STEP apply to VSTARS, and why would we consider it a STEP success story? After all, Joint STARS is a fielded system, and VSTARS was developed for a joint test. This question is best answered by reviewing the definition of STEP as contained in the Simulation, Test and Evaluation Process (STEP) Guidelines, 4 Dec 97.

“The Simulation Test and Evaluation Process is defined as an iterative process that integrates simulation and test for the purpose of interactively evaluating and improving the design, performance, joint military worth, survivability, suitability, and effectiveness of systems to be acquired and improving how those systems are used.”

The key phrase for us to consider in this definition is that STEP is defined as an iterative process. Joint STARS is a fielded system, true, but it is hopefully only at the beginning of its life cycle. If the examples set by similar systems, such as the Airborne Warning and Control System, are valid, it will undergo many more iterations before being retired. Therefore, if VSTARS can be successfully integrated with testing for the purpose of interactively evaluating and improving the design, performance, joint military worth, survivability, suitability, and effectiveness of Joint STARS, then VSTARS is a STEP success story.

Joint STARS - Almost STEP

Prior to describing how VSTARS can be integrated into the testing and acquisition process for Joint STARS, it is first necessary to review the program and its applicability to STEP. As stated, Joint STARS is a fielded system that existed prior to Dr. Paul Kaminski's announcement requiring STEP to be a part of future test and evaluation master plans. A review of the Joint STARS program, however, reveals that many of the practices, and even more importantly, the resources needed by STEP are present and in use by the developers and testers of the system. There exists today an extensive set of laboratory facilities, component test facilities, subsystem simulators, hardware-in-the-loop facilities, engineering models, and subsystem simulations that are used to support the development and testing of Joint STARS.

What was missing was a system representation which due to the distributed nature of the system would require a distributed simulation. This system representation would provide the ability to evaluate the design, performance, joint military worth, survivability, and effectiveness of Joint STARS as a whole. As an aside, up to now this evaluation or testing has primarily required physical prototypes, test aircraft, and costly field trials.

The Success Story

We at JADS consider VSTARS to be that missing system representation. To validate that belief, I would like to describe how VSTARS can be integrated with testing for the purpose of interactively evaluating and improving the design, performance, joint military worth, survivability, suitability, and effectiveness of Joint STARS. In addition, I will describe how VSTARS can, and most likely will, be used in the development of training simulators with the requisite realism and fidelity for system operators and maintainers.

Developmental Testing

VSTARS was designed so that the only true simulation is the simulation of the MTI and SAR radar modes taking place within the radar subsystem. Everything else is either integration code or actual E-8C system code. The inputs into VSTARS, except for the target data, are the inputs into the real radar processor, and the outputs are the actual radar reports. The radar simulations are parallel processes with the radar when live and virtual are mixed and solve the radar equations in order to achieve the required fidelity.

This architecture allows the use of VSTARS to conduct developmental testing of all of the other subsystems that comprise Joint STARS, provided VSTARS is an accurate representation of the radar. Obviously, VSTARS cannot be used to conduct developmental testing of the radar subsystem.

As an example, one of the features of the workstation used on the E-8C is an automatic tracker (A-tracker). The A-tracker works off radar reports and when initiated will automatically track a designated formation providing bearing, speed, and number of vehicles. Prior to VSTARS, it was necessary to either have a functioning radar (test flight) or a recording of a functioning radar in order to test the A-tracker. Test cases were basically limited to those that could be achieved at Eglin Air Force Base, Florida, with a minimal number of vehicles traveling under peacetime safety restrictions.

Northrop Grumman is currently developing an annual release of the radar software that will incorporate a revised version of the A-tracker software. Parallel to the normal testing of the new A-tracker software, Northrop Grumman also conducted a study to determine if VSTARS could be used to test this software. They found that both the old and new versions of the A-tracker software functioned as expected with VSTARS. The old version also functioned the same as it did using the live radar, which was to be expected as the radar reports it uses are identical.

The findings from this study were encouraging and verify some of the premises of STEP. Test cases could be “flown” using VSTARS whenever needed with as many repetitions as desired. This was possible without competing for scarce test aircraft and range resources. Cost was a “no brainer.” One tester and two computers in a lab vice the aircraft, testers, crew, and range assets required for a live test. Any conceivable test case could be “flown” without worrying about safety or limited assets. Bad solutions could be quickly discarded, and new, better solutions could be tried the next day. Most importantly, when a live test flight is flown, as it must be, the testers can be reasonably sure that they will get the maximum value from the flight and test conditions.

Operational Testing

Operational testing (OT), early operational assessments, and the development of tactics, techniques and procedures are all areas where STEP will make a large impact. As systems become larger and more complex, it becomes more and more difficult to effectively test them. This was the case with Joint STARS, a corps- or theater-level C4ISR system that was scheduled

to be tested with a brigade-level force. Operational testing of a C4ISR system, specifically Joint STARS, has been the main thrust of the JADS End-To-End Test.

To date, JADS ETE has conducted a laboratory-based operational test of Joint STARS and an operational assessment of the ability of Joint STARS to interact with the Army's All Source Analysis System (ASAS). The Joint STARS radar information was used, along with other intelligence sources, to determine targets for engagement by a virtual Army Tactical Missile System (ATACMS). Additional details may be found in another paper presented at these proceedings entitled ETE Update - ADS Testing of C4ISR Systems.

By using ADS and VSTARS, JADS ETE was able to place a simulated Joint STARS in a realistic operational environment and collect valid data for the evaluation of operational measures. Additionally, though not early, operational assessments were made as to the ability of Joint STARS to accurately detect and report on potential ATACMS targets. Finally, numerous tactics, techniques and procedures were developed covering the interaction of Joint STARS and ASAS during the training and rehearsal periods of the test.

In the March timeframe, JADS ETE will again conduct an operational test of Joint STARS and an operational assessment of the ability of Joint STARS to interact with the Army's All Source Analysis System. The major difference will be the use of an actual ADS-augmented E-8C for two of the test days. Joint STARS will see both real and virtual targets under various clutter conditions while operating in a realistic operational environment and collecting data for the evaluation of operational measures.

Training

The Simulation, Test and Evaluation Process (STEP) Guidelines state that STEP can aid in the development of training simulators with the requisite realism and fidelity for system operators and maintainers. Such is the case with VSTARS. It is currently being integrated into the current Mission Crew Training System as a prototype system and, if successful, will likely be the new trainer for the Air Force.

The Future

As stated earlier, STEP is applicable for the entire life cycle of the system. Like all systems, Joint STARS is constantly undergoing improvement and upgrades. Inquiries have been made as to the possibility of using VSTARS for the Joint STARS Block 2 follow-on OT&E. In addition, the Joint STARS Joint Test Force is currently extending the V&V of VSTARS so that, if within specifications, VSTARS may be accredited for use in the testing of subsystems such as the A-tracker or a modified operator workstation. Also, if the decision is made to retest the common ground station (CGS), VSTARS could be used to solve or answer many of the faults found in the first test. For example, operators can easily be trained on the new CGS, and joint tactics, techniques and procedures can be developed and practiced using a synthetic environment similar to that used by the JADS End-to-End Test.

Northrop Grumman is also interested in using appropriately modified versions of VSTARS to provide early operational assessments of proposed product improvements to the radar used by Joint STARS. Also, if the product improvements are authorized, VSTARS could then be used to (1) verify the system's design; (2) confirm that design risks have been controlled; (3) certify readiness for operational testing; and (4) evaluate the system's operational effectiveness, suitability, and survivability.

Conclusions

Last year at the ITEA conference in Orlando, Florida, Dr. Patricia Sanders, Director, Test, Systems Engineering and Evaluation stated the implications of STEP to the acquisition community.

- Testers will be involved much earlier in an acquisition program.
- Predictions of system performance can be made to assess the military worth of the system before any physical prototypes are built.
- Predictive simulations can be used to expand the scope of system testing and evaluate system performance in areas that are not readily testable.
- The models, simulations, and test data will have a much wider use throughout the system's life cycle.

The implications of VSTARS to the Joint STARS acquisition community are the same.

- Both DT and OT testers will be involved much earlier in the product improvement program.
- Predictions of system performance will be made to assess the military worth of the system before any physical prototypes are built.
- Predictive simulations will be used to expand the scope of system testing and evaluate system performance in areas that are not readily testable.
- The models, simulations, and test data will have a much wider use throughout the remainder of the system's life cycle.